



## Spray Analysis Report

Customer Information: [REDACTED]  
Sample Information/ID: Resin study with Graco Medium Duty Sprayer  
Analyst: KButz  
Instrument: MAL1055256  
Quote/Invoice No: MOM-1

### Summary:

One 2 quart sample of [REDACTED] (Resin) was used with the Graco Medium Duty paint sprayer outfitted with the 411 and 515 spray nozzles. The spray system was run under three different pressures to evaluate droplet size under different conditions that mimic worst case scenario for usage. The entire 2qt sample was used in the testing.

The pressures used were estimates based on the Graco system being outfitted with a dial and no numerical readout. The full range of the sprayer is 0-3300psi. The approximate pressures used for the testing were 2600psi, 2100psi and 1600psi. The dial was adjusted accordingly to effort these test conditions. In the remainder of this report, 2600psi will be called high, 2100psi will be called medium and 1600psi will be called low.

The sprays were investigated for droplet size distribution and the final testing was performed as follows:

- Distance from measurement zone: approx. 12 inches
- Data collected in triplicate over 1s at acquisition rate of 100Hz with 300 mm lens
- Results obtained by averaging the entire spray
- Beam steering was corrected for in all analysis
- Sprayer was primed prior to testing
- Sprayer was moved throughout the spray fan to capture information on full spray

The full data reports for the testing are attached to the email including this report. If you have any questions/concerns about the data presented in this report, please contact us to discuss the results in further detail.

Thank You  
Kyle Butz

**Results:**

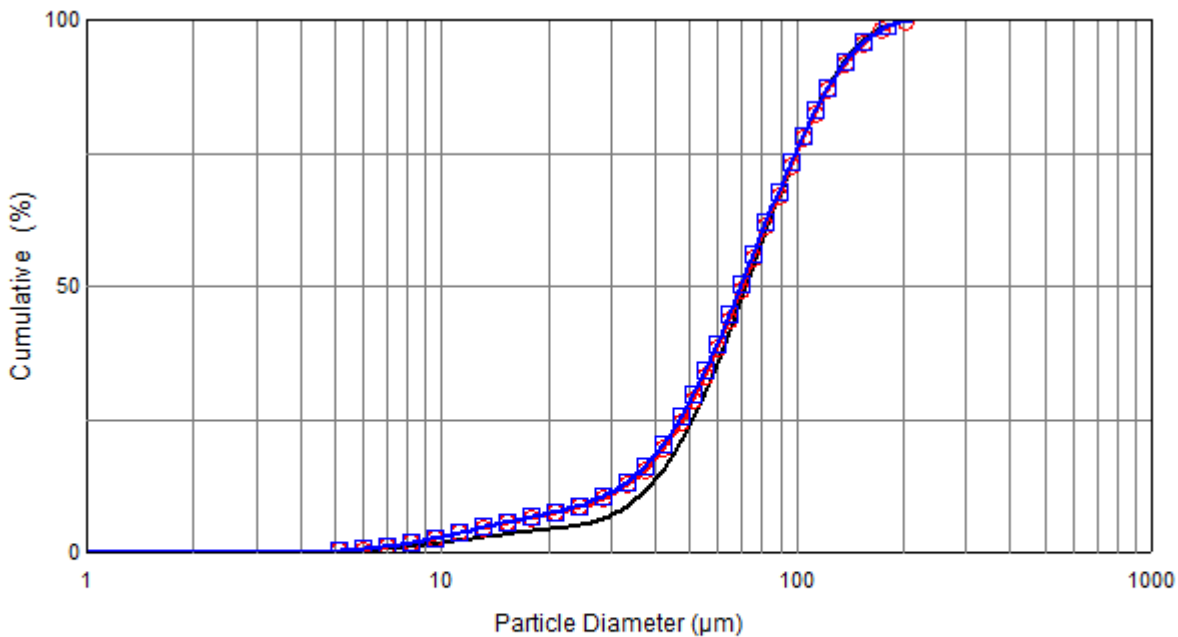
The final averaged data is presented in the attached individual DSD reports. Below is a summary table of the results and averages.

	Dv(10)	Dv(50)	Dv(90)	%V < 10um
Nozzle 515 High Pressure 1	34.937	74.636	135.912	1.814
Nozzle 515 High Pressure 2	37.007	80.512	148.399	2.074
Nozzle 515 High Pressure 3	42.729	90.041	169.976	1.767
Average	38.224	81.729	151.429	1.885
Nozzle 515 Medium Pressure 1	41.367	86.955	162.440	1.035
Nozzle 515 Medium Pressure 2	34.957	81.160	149.774	1.886
Nozzle 515 Medium Pressure 3	39.703	85.498	155.951	1.921
Average	38.676	84.538	156.055	1.614
Nozzle 515 Low Pressure 1	55.552	119.970	273.406	0.218
Nozzle 515 Low Pressure 2	44.042	110.820	286.999	0.784
Nozzle 515 Low Pressure 3	45.170	109.480	234.126	0.830
Average	48.255	113.423	264.844	0.611
Nozzle 411 High Pressure 1	35.364	72.385	128.474	1.812
Nozzle 411 High Pressure 2	28.475	70.856	130.403	2.842
Nozzle 411 High Pressure 3	27.434	69.920	129.386	2.942
Average	30.424	71.054	129.421	2.532
Nozzle 411 Medium Pressure 1	46.541	87.372	153.011	0.943
Nozzle 411 Medium Pressure 2	45.446	89.264	158.195	1.458
Nozzle 411 Medium Pressure 3	NA	NA	NA	NA
Average	45.993	88.318	155.603	1.200
Nozzle 411 Low Pressure 1	NA	NA	NA	NA
Nozzle 411 Low Pressure 2	NA	NA	NA	NA
Nozzle 411 Low Pressure 3	NA	NA	NA	NA
Average	NA	NA	NA	NA

- NA is insert into the table due to the spray nozzle clogging under these conditions. The 411 nozzle was found to clog beginning at the medium pressure setting. Therefore, the third test at medium pressure was not able to be completed and none of the low pressure tests were completed. The high pressure setting should provide worst case scenario for usage.

## Analysis:

*Overlay of repeat measurements under identical conditions*



	Sample	Dx(10)	Dx(50)	Dx(90)
—■—	[V] Graco 411 Nozzle High Pressure	35.36	72.39	128.47
—●—	[V] Graco 411 Nozzle High Pressure	28.47	70.86	130.40
—■—	[V] Graco 411 Nozzle High Pressure	27.43	69.92	129.39

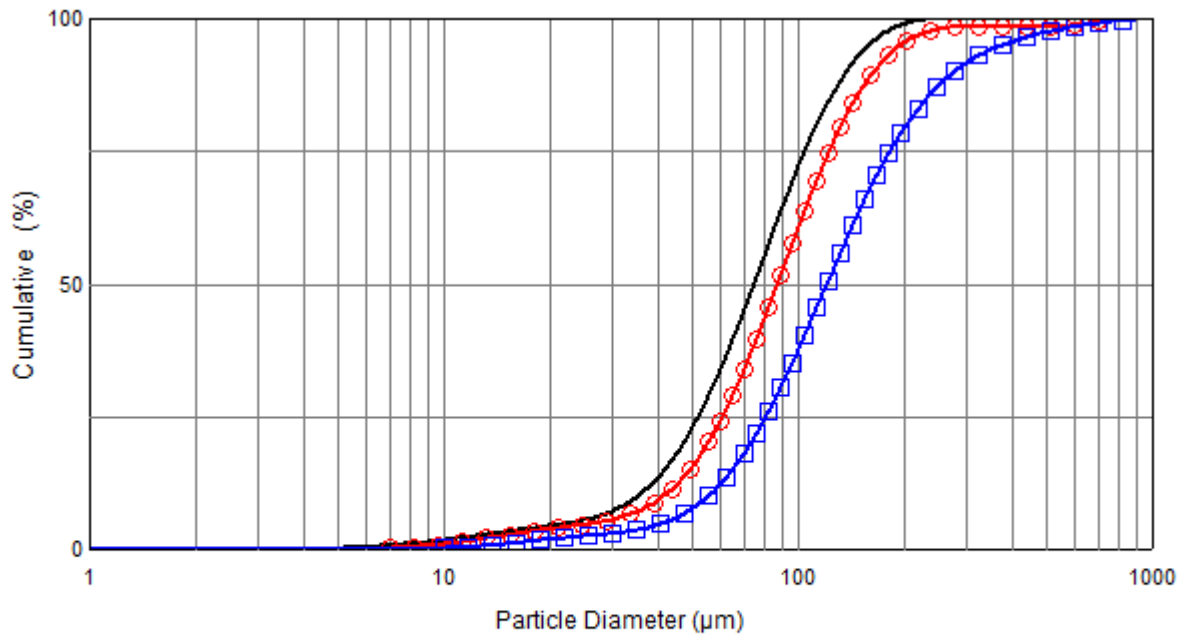
Above is the cumulative overlay plot of the 411 Nozzle under high pressure to evaluate the repeatability of the results. In looking at this curve, the droplet size distribution is displayed from left to right as smallest to biggest in a cumulative manner. The left side of the plot is indicative of the smallest droplets created while the right side of the plot is indicative of the largest droplets created.

The results above are very consistent as marked by three tightly grouped cumulative curves for droplet size distribution. This indicates once the sample is being sprayed by the Graco sprayer, there is consistency in the output. This generally means the pressure is being kept stable at the orifice to produce consistency in final spray pattern and droplet size. Similar consistency of droplet size distribution was observed for all tests with the 515 nozzle.

The one caveat to the consistency was found in the 411 nozzle at lower pressures where the small orifice clogged and there was no spray pattern output. This would indicate if the 411 nozzle was used, the operating pressure must be in the upper end of the range to have a chance at success. The 515 nozzle did not experience clogging issues during the testing.

## Analysis (cont):

### Cumulative Overlay of 515 Nozzle at High, Medium and Low Pressure



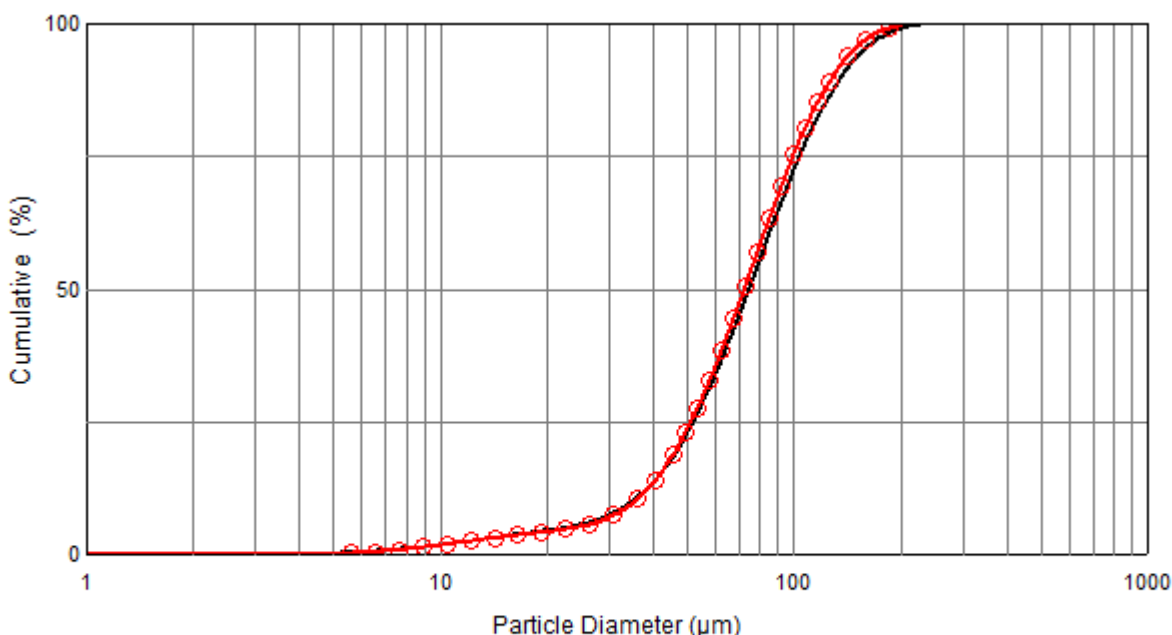
	Sample	Dx(10)	Dx(50)	Dx(90)
—V—	Graco 515 Nozzle High Pressure	34.94	74.64	135.91
—○—	Graco 515 Nozzle Medium Pressure	41.37	86.95	162.44
—□—	Graco 515 Nozzle Low Pressure	55.55	119.97	273.41

Above is the cumulative presentation of the 515 Nozzle under the three pressure conditions. In looking at the curves, the left most curve (high pressure) shows the smallest droplet size while the right most curve (low pressure) shows the largest droplet size.

The relationship between pressure and droplet size is seen above with the highest pressure outputting the smallest droplet size and the lowest pressure having the largest droplet size. This is expected as pressure is increased, the droplet size corresponding is expected to decrease. The triplicate analysis showed the high and medium pressures being very closely grouped to one another. This may be related to the resin characteristics.

## Analysis (cont):

### Nozzle vs Nozzle comparison



	Sample	Dx(10)	Dx(50)	Dx(90)
—○—	[V] Graco 515 Nozzle High Pressure	34.94	74.64	135.91
—○—	[V] Graco 411 Nozzle High Pressure	35.36	72.39	128.47

Above is the comparison of the two nozzles run at high pressure.

These results are nearly identical indicating the orifice size at high pressure is not causing a large change in droplet size. In general, a smaller orifice size causes a smaller droplet size. However in this case, it is not observed. The resin sample characteristics is likely the cause as the results are nearly identical from any practical standpoint.

### Inhalation Hazard

Droplet sizes under 10µm are often considered an inhalation hazard. In the study conducted, material was observed under 10µm under the nozzle and pressure conditions used. The amount varied from less than 1% at lower pressures to upwards of 2-3% at higher pressures with the nozzles utilized in testing. The 411 nozzle at high pressure, as would be expected, produced the most sub 10µm material. This information should be considered when indicating normal operating conditions to ensure safe usage with the material and sprayer.

## Understanding Your Droplet Size Study

### *Testing Procedure:*

The Malvern Spraytec was used for analysis and each spray was tested at approximately twelve inches from the detector beam.

The spray measurements were made in triplicate with results summarized above and attached for full review

The sample was sprayed consistently and moved to measure the full spray fan.

The 411 nozzle clogged under the medium pressure and was unable to be cleared once it was clogged so no low pressure testing was able to be performed and two data points only were collected at medium pressure. It appears the samples stickiness was the cause.

In the testing performed, the entire 2qt sample was used.

### *Discussion Points:*

**Beam Steering** – Beam steering is a phenomenon in droplet size testing of aerosols where propellant causes false peaks of very large droplets to be apparently measured. From a measurement standpoint, this is caused by a change in the refractive index of the measurement zone. It is observed by the instrument's inner detectors. These detectors, when testing aerosols similar to the sample submitted, can be ignored in the analysis.

**% < 10um Reporting** – The percentage of spray by volume at droplet sizes of 10um and less is thought to be inhalable and often requested in health and safety studies for consumer goods. The values obtained in this study are reported in the attachments for each individual spray.

### *Understanding the Report:*

The data report following includes several size distribution values. The most commonly used values are defined below:

**Dv(10)** – Indicative of the 10<sup>th</sup> percentile by volume of the spray.

**Dv(50)** – Indicative of the 50<sup>th</sup> percentile by volume of the spray. The median droplet size

**Dv(90)** – Indication of the 90<sup>th</sup> percentile by volume of the spray

**Span** – A calculation of breadth of distribution noted by  $(Dv(90)-Dv(10))/Dv(50)$

**% Volume < (um)** – Measurement of the sample below a specific droplet size.

**D[4,3]** – Volume weighted mean of a spray.

**D[3,2]** – Surface weighted mean of a spray.